

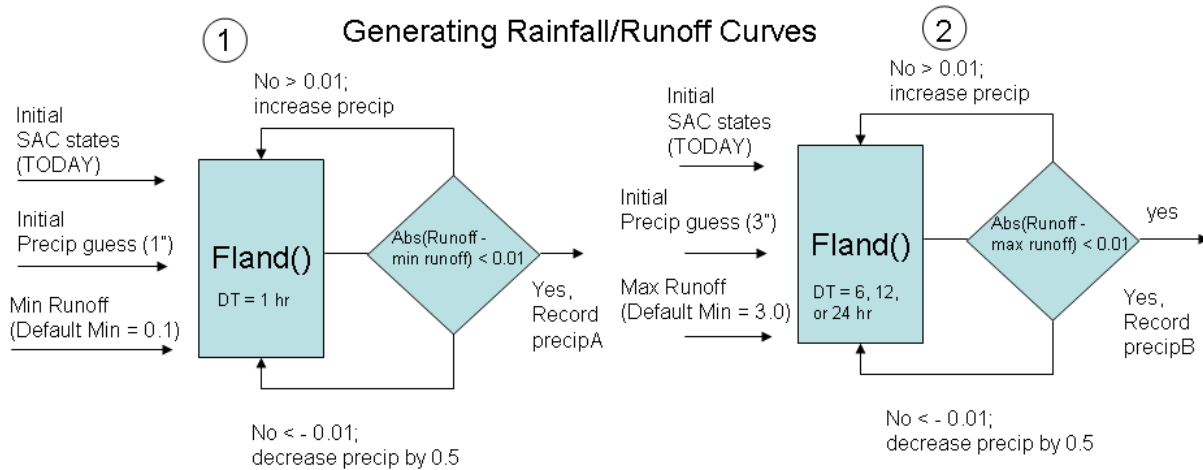
FFH and Gridded FFG

There are many things common between the two programs FFH and Gridded FFG. This document list the common features shared by both. For specifics, please see:

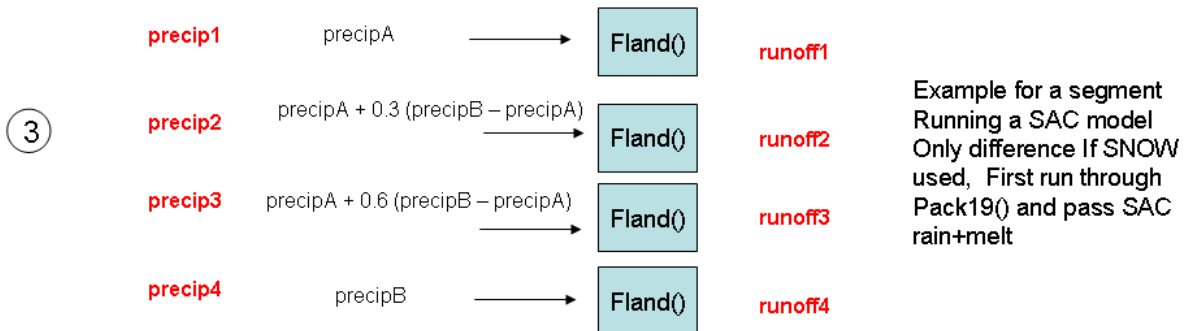
[Flash Flood Guidance for Headwaters \(FFH\)](#)

[Flash Flood Guidance for Counties/Areas \(Gridded FFG\)](#)

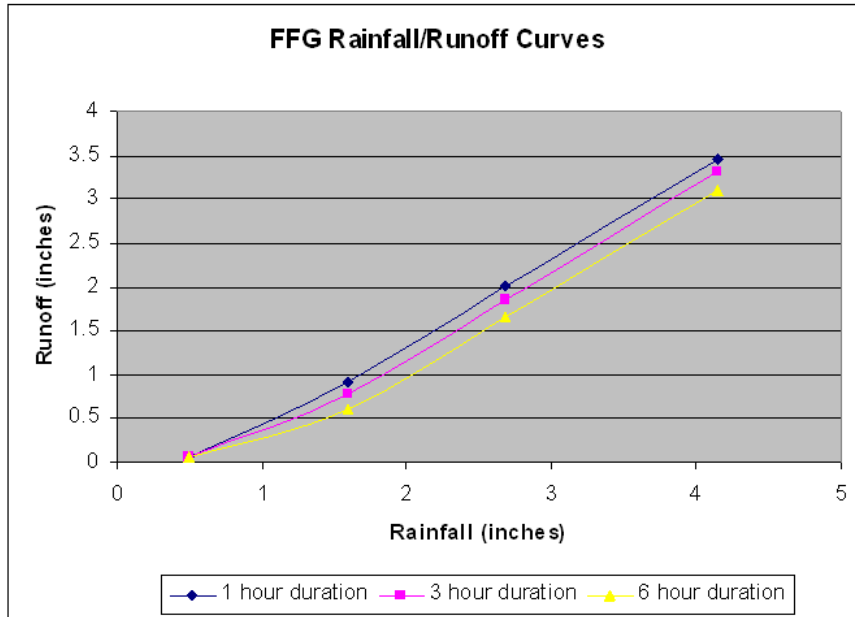
1. Generating Rainfall/Runoff Curves



For each duration (1,3,6, 12 (optional), 24 (optional))



Rainfall/Runoff Curves



Use previously
Computed
Values to generate
Rainfall- runoff
Curves

THRES-R used
To compute
FFH from curves

2. Parameters shared by FFH and Gridded FFG

Name	Type	Required [Yes/No]	Comment
“Default” Parameters			
LOCATION_ID	String ¹	Yes	For FFH, this is location identifier for headwater. For Gridded FFG, this is equal to sole area Id.
RUNOFF_ADJUST_ OPTION	String ¹	Yes	The method (if any) for adjusting the THRESH-R value for runoff. It can have the following choices(the number inside the parenthesis is the legacy equivalent number): "NO_ADJUSTMENT"(0) "ADJUST_RUNOFF"(1) "USE_FIELDS_AS_FFG"(2) "USE_THRESHOLD_RUNOFF_AS_FFG"(3) "ADJUST_FFG"(5) "EXCLUDE FROM GRID COMPUTATIONS"(9)[5 & 9 used only by Gridded FFG]

Name	Type	Required [Yes/No]	Comment
USER_CTRL_ RUNOFF_ADJUST	Boolean	Yes	Enable/disable the runoff adjust option (if false, the parameter RUNOFF_ADJUST_OPTION value is treated as "NO_ADJUSTMENT". (For the legacy system, this User Control is optional. The default value is true.)
HIGH_FLOW_ ADJUST_OPTION	String ¹	No	The method (if any) for obtaining the max forecast flow. It can have the following choices(the number inside the parenthesis is the legacy equivalent number): "NO_ADJUSTMENT"(0) "FORECAST_FLOW_AT_HOURS"(1) "HIGHEST_FORECAST_FLOW_OVER_NEXT_HOURS"(2) "HIGHEST_FORECAST_FLOW_IN_TIMESERIES"(3) "REDUCE_RUNOFF_BY_STORM_RUNOFF" (4)[4 used only by FFH]
USER_CTRL_HIGH_ FLOW_ADJUST	Boolean	Yes	Enable/disable the high flow adjust option HIGH_FLOW_ADJUST_OPTION. (For the legacy system, this User Control is optional. The default value is true.)
USER_CTRL_ CHECK_ DECREASING_FFG	Boolean	Yes	If true and the next ffg value is less than the previous one, re-set it to the previous value. (For the legacy system, this User Control is optional. The default value is false.)
PERCENT_ IMPERVIOUS	Double [unitless]	Yes	Decimal fraction, between 0.0 and 1.0
MIN_MAX_ VALUES_1_HOUR MIN_MAX_ VALUES_3_HOUR MIN_MAX_ VALUES_6_HOUR MIN_MAX_ VALUES_12_HOUR MIN_MAX_ VALUES_24_HOUR	Table [inch]	Yes	Only one row with two columns with double values: the min and max FFH value allowed, if the computed is smaller/larger than the min/max, it is reset to this value.
ADJUST_FLOW_ TIME_1_HOUR ADJUST_FLOW_ TIME_3_HOUR ADJUST_FLOW_ TIME_6_HOUR ADJUST_FLOW_ TIME_12_HOUR ADJUST_FLOW_ TIME_24_HOUR	integer	depends	Timing information for Adjust option used; required when FFG_HIGH_FLOW_ADJUST_OPTION has choices equivalent to legacy 1, 2 or 3.

Name	Type	Required [Yes/No]	Comment
THRESHOLD_RUNOFF_1_HR_IN_INCHES THRESHOLD_RUNOFF_3_HR_IN_INCHES THRESHOLD_RUNOFF_6_HR_IN_INCHES THRESHOLD_RUNOFF_12_HR_IN_INCHES THRESHOLD_RUNOFF_24_HR_IN_INCHES	Double for FFH; Table for Gridded FFG [INCH]	depends	A).For FFH, if the parameter FFH_UNIT_HG_PEAK_X_HR_IN_CFS_P R_INCH is not present, this parameter is required. The threshold runoff values are directly from the parameter file; if FFH_UNIT_HG_PEAK_X_HR_IN_CFS_P R_INCH is present, this parameter is not required, since the threshold runoff values will be calculated. B). For Gridded FFG, these parameters are always needed and they are tables, not single double value.
FFG_INTENSITY_3_HOUR FFG_INTENSITY_6_HOUR FFG_INTENSITY_12_HOUR FFG_INTENSITY_1_HOUR FFG_INTENSITY_24_HOUR	Double	No	Depends on value for RUNOFF_ADJUST_OPTION A) For ADJUST_RUNOFF"(1) values are factors to apply to runoff B) For USE_FIELDS_AS_FFG values are FFG in GRIDDEDFFG calculation C) For USE_THRESHOLD_RUNOFF_AS_FFG FFG values are THRESHR values for FFH calculations D) For ADJUST_FFG values are multipliers to apply to FFG computed during GRIDDEDFFG calculations

¹String is case-insensitive

Note: Example of the parameter THRESHOLD_RUNOFF_X_HR_IN_INCHES:

i)For FFH:

```
<parameter id="THRESHOLD_RUNOFF_1_HR_IN_INCHES">
  <dblValue>0.38</dblValue>
</parameter>
```

ii)For Gridded FFG:

```
<parameter id="THRESHOLD_RUNOFF_1_HR_IN_INCHES">
  <table>
    <columnIds A="SEGMENT" B="HRAP_ROW" C="FIRST_HRAP_COLUMN"
D="LAST_HRAP_COLUMN" E="THRESHOLD_RUNOFF_VALUE_IN_INCHES"/>
    <columnTypes A="int" B="int" C="int" D="int" E="double"/>
    <row A="1" B="404" C="886" D="887" E="0.48976377952755906"/>
    <row A="1" B="403" C="887" D="888" E="0.48976377952755906"/>
    <row A="1" B="402" C="887" D="888" E="0.48976377952755906"/>
    <row A="1" B="401" C="886" D="889" E="0.48976377952755906"/>
    <row A="1" B="400" C="888" D="888" E="0.48976377952755906"/>
  </table>
</parameter>
```

</table>
</parameter>

Name	Type	Required [Yes/No]	Comment
Parameters for each area			
FFG_SEGMENT_ID	String ¹	Yes	Segment identifier. Only used by migration script. Not used by model computation.
FFG_DURATION	String ¹	Yes	The durations to compute FFH values for. It has three choices: "1_3_6_HR", "1_3_6_12_HR" and "1_3_6_12_24_HR". If running multiple areas, each area should have the same value.
FFG_MINIMUM_THRESHOLD_RUNOFF	Double [inch]	No	The minimum runoff for generating rainfall-runoff curves. When the parameter is absent or is present with value of 0.0, use 0.1.
FFG_MAXIMUM_THRESHOLD_RUNOFF	Double [inch]	No	The maximum runoff for generating rainfall-runoff curves. When the parameter is absent or is present with value of 0.0, use 2.5.
FFG_RAINFALL_RUNOFF_MODEL_NAME	String ¹	Yes	The name of the rainfall-runoff model used at this location. It has only two choices: "SAC-SMA" or "API-CONT"
FFG_RAINFALL_RUNOFF_MODEL_ID	String ¹	Yes	The id of the rainfall-runoff model used at this location, equivalent to the legacy operation name, used to retrieve the parameters and states.
FFG_SNOW_MODEL_NAME	String ¹	No	The absence or presence of this parameter determines whether or not running the model SNOW-17 before running the rainfall runoff model. If it is present, the String value can only be "SNOW-17".
FFG_SNOW_MODEL_ID	String ¹	Depends	Required when running snow model. The id of the snow model at this location, equivalent to the legacy operation name, used to retrieve the parameters and states.

¹String is case-insensitive

Note: FFH and GriddedFFG Calculation in CHPS allows SAC-SMA and API-CONT as possible RAINFALL-RUNOFF models and SNOW17 as the SNOW model. These model(s) parameters are also needed.

[SAC-SMA](#)
[API-CONT](#)
[SNOW17](#)

3. Utility States

The FFH algorithm does not use any of its own states.

Note: Both FFH and Gridded FFG calculation in CHPS allows SAC-SMA and API-CONT as possible RAINFALL-RUNOFF models and SNOW17 as the SNOW model. These model(s) states are also needed.

[SAC-SMA](#)
[API-CONT](#)
[SNOW17](#)

However, for Gridded FFG, for the first grid of RFC, the states metafile is needed and its <readLocation> element defines the input NETCDF file, since <inputNetcdfFile> element is missing in run_info.xml. The states metafile is specified in run_info.xml <properties> section with key of "griddedFfgStates":

```
<properties>
...
<string key="griddedFfgStates" value="Modules/ffg/griddedFfg/test/states/states.xml"/>
...
</properties>
```

For all the other grids, <inputNetcdfFile> element is present in run_info.xml, so no need to have states meta file.

4. Utility Time Series

INPUT TIMESERIES:

Time Series Type	Internal Model Units	Time Step	Missing Values Allowed	Required [Yes or No]
Discharge	CMS	Any	No	No <u>1</u> /
MAT	DEGC	Any	No	Yes for snow model or SAC-SMA FRZE <u>2</u> /

Notes:

1/: In some conditions, FFH needs two pieces of information from the discharge time series (the <thresholds> element in the header and the discharge time steps in the body), while Gridded FFG will only need the discharge time steps on some conditions:

a). For FFH only: when FFH parameter "FFH_USE_THRESHOLD_FOR_FLOOD_FLOW" is true, it is required to have <thresholds> element in the header part of the time series. It provides bankfull flood flow value (unit CMS). Gridded FFG never needs <thresholds> element since it gets the threshold runoff value of individual grid directly from its parameter xml file. Further explanation is provided below.

b). The discharge time steps in the time series body is not needed for both FFH and Gridded FFG when the parameter "HIGH_FLOW_ADJUST_OPTION" is "NO_ADJUSTMENT" or "REDUCE_RUNOFF_BY_STORM_RUNOFF". In another word, it is required for both FFH

and Gridded FFG when the parameter “HIGH_FLOW_ADJUST_OPTION” is one of "FORECAST_FLOW_AT_HOURS", "HIGHEST_FORECAST_FLOW_OVER_NEXT_HOURS" and "HIGHEST_FORECAST_FLOW_IN_TIMESERIES".

Below is further explanation about the difference between FFH and Gridded FFG regarding to the need of input discharge time series, including the <thresholds> element in the header. The input discharge time series is used to compute the Threshold runoff, the average runoff in inches over an area required to fill a channel.

A). For FFH, the Threshold runoff values can be either directly obtained from parameters “THRESHOLD_RUNOFF_x_HR_IN_INCHES” (then no need of the input discharge time series) or calculated (then need the input discharge time series).

$$TR = Qb/Qp$$

TR is threshold runoff [inch].

Qb is bankfull flow [cfs] – could be from discharge time series header <thresholds> element or the parameter "FFH_FLOW_AT_FLOOD_STAGE_IN_CFS", depending on the Boolean parameter "FFH_USE_THRESHOLD_FOR_FLOOD_FLOW".

Qp is the unit hydrograph peak flow [cfs/inch].

When high flow adjustment is on (the parameter HIGH_FLOW_ADJUST_OPTION is one of these: "FORECAST_FLOW_AT_HOURS", "HIGHEST_FORECAST_FLOW_OVER_NEXT_HOURS" and "HIGHEST_FORECAST_FLOW_IN_TIMESERIES"), **Qb** (bankfull flow) is adjusted (in fact, reduced) based on the parameter HIGH_FLOW_ADJUST_OPTION value and the discharge time series.

Note:

- 1) Being consistent with NWSRFS, when the <thresholds> element in discharge time series header is negative value, the model computation is skipped. All the ffg values are set to -9.8 as missing value;
- 2) The discharge time series parameterId not necessarily be “QINE”. It can be other discharge type time series, e.g. QIN.

B). For Gridded FFG, discharge time series is only needed when high flow adjustment is on. The ratio “max forecast flow/bankfull flow” is used to reduce the threshold runoff value for each grid. The threshold runoff values are always from the parameter table “THRESHOLD_RUNOFF_x_HR_IN_INCHES”.

2/: The input MAT time series is required for Snow17 or SACSMA frozen ground. Its length needs to start from the last observation date to next 6 hour, 12 hour or 24 hour, depending on FFG_DURATION parameter. All the other input time series for the original Snow17 model are not needed:

- The input precipitation time series (MAP) is not needed, because FFH program uses try/error strategy to find the expected precipitation value producing the target runoff value.
- The input percentage snow fall time series (PTPS) for Snow17 is not needed, because the precipitation is treated as 100% rain.
- The input rain snow elevation time series (RSEL) is not needed, because it is treated as missing value.
- The input MAPE time series for runoff model (SACSMA or API-Cont) is not needed either.

If running multiple areas (only FFH does, Gridded FFG only run one area), multiple input MAT time series are needed for each area. They are located in input/areaId/inputs.xml files. The directory name (e.g. “areaId” in this example) designate which area it is.

API-Cont model does not need the input MAT time series or any other input time series.

OUTPUT TIMESERIES For FFH:

Time Series Type	Internal Model Units	Time Step	Missing Values Allowed	Required [Yes or No]
Flash Flood Guidance for Headwaters (FFH)	Inches	1, 3, 6, 12*, 24*	Yes	Yes

* 12 and 24 hour time series are optional

The output time series file (outputs.xml) contains 3 time series (with interval of 1 hour, 3 hour and 6 hour), 4 time series (plus additional time series with interval of 12 hour) or 5 time series (plus another one with interval of 24 hour), depending on the parameter “FFG_DURATION”. The time series only has one time step, corresponding to the initial state time plus the interval.

The output result for Gridded FFG is a NETCDF file holding all the grids of the RFC.

5. Notes about configuring Utility in FEWS workflow

A). Parameters and States:

The parameter file for FFH or Gridded FFG is specified in the properties section of run_info.xml with key of "ffgParameters".

For FFH, the parameter xml file contains one “default” group parameters, which is common for all the areas and at least one area’s specific group parameters. If FFH is running in multiple areas, it will contain each area’s specific parameters. For Gridded FFG, the parameter xml file always contains one “default” group parameters and one area’s specific parameters.

Regarding to the parameters and the states meta files for the models (SNOW-17, SAC-SMA and API-Cont), their locations are specified in run_info.xml properties section too:

```
<properties>
...
  <string key="ffgParameters" value="Modules/ffg/ffh/test/input/paramsFFH.xml"/>
  <string key="runoffModelParametersRootDir"
value="Modules/ffg/ffh/test/input/sacsma"/>
  <string key="runoffModelStatesRootDir" value="Modules/ffg/ffh/test/states/sacsma"/>
  <string key="snowModelParametersRootDir"
value="Modules/ffg/ffh/test/input/snow17"/>
  <string key="snowModelStatesRootDir" value="Modules/ffg/ffh/test/states/snow17"/>
...
</properties>
```

So, the parameter xml file for SNOW-17 will be located in "Modules/ffg/ffh/test/input/snow17/areaId/" and the states meta file in "Modules/ffg/ffh/test/states/snow17/areaId/" (areaId from the FFG parameter xml file, pointed to by "ffgParameters"). When FFH is running in multiple areas, there will be multiple subdirectories under "Modules/ffg/ffh/test/input/snow17" and "Modules/ffg/ffh/test/states/snow17", with each subdirectory name equal to one area id.

If running API-CONT model, the following is also needed be inside the properties to indicate the executable binary file location:

```
<string key="legacyLocation" value="xx/xx/bin"/>
```

The properties element “FloodFlowId” is used to search through input discharge time series header section to get the corresponding threshold.

```
<string key="FloodFlowId" value="FF"/>
```

B). Run-Time Options (known as TECHNIQUES in NWSRFS):

Both FFH and Gridded FFG allows for two run-time options. When specified they should appear in the run_info.xml file:

```
<properties>
    <string key="FROST" value="true"/>
    <string key="SNOW" value="true"/>
    ...
</properties>
```

- i) SNOW – when the parameter defines to run SNOW17 model, the following line within run_info.xml properties section can override it and turn off SNOW17:

```
<string key="SNOW" value="false"/>
```

If this line is missing, the SNOW TECHNIQUE default value is “true”.

- ii) FROST – when running SAC-SMA rainfall runoff model with the Frozen Ground algorithm, the following line will turn off its frozen ground feature and just run the regular SAC-SMA model. If not planning to run the Frozen Ground algorithm originally, by the definition of the parameter file, the FROST TECHNIQUE of “false” will be ignored and have a WARNING message.

```
<string key="FROST" value="false"/>
```

If this line is missing, the FROST TECHNIQUE default value is “true”.

6. FEWS Adapter Used

The FFH utility uses the OHDFewsadapter to communicate. Information about this adapter can be found at [OHDFewsadapter](#).

7. Model Differences

a) SACSMA

The following SACSMA parameters are not needed when running in FFG, comparing to the standalone SACSMA model:

- i) "ET_DEMAND_CURVE", "MAPE_INPUT": Evapotranspiration is treated as 0.0. SACSMA in FFG does not use input MAPE time series either.
- ii) "SASC_INPUT_OPTION": SACSMA in FFG does not use input SASC time series, because evapotranspiration is treated as 0.0.
- iii) "WE_INPUT_OPTION": this parameter is used in standalone SACSMA when running frozen ground and the optional input SWE time series is needed when the parameter is true. However, FFG SACSMA with frozen ground does not use this parameter or the input SWE time series.
- iv) "RUNOFF_COMPONENT_INTERVAL": SACSMA in FFG does not output runoff component time series.
- v) "SMZC_INTERVAL": SACSMA in FFG does not output soil moisture storage time series.

The SACSMA running in FFG does not use mods. However, SACSMA techniques (FROST, PRINTSMA and SACSNEW) are still used.

b) SNOW17

If the FFG program executes SNOW17 model, there are some small differences, comparing to the standalone SNOW17 model:

- i) The input percentage snow fall time series (PTPS) for Snow17 is not needed, because the precipitation is treated as 100% rain.
- ii) Does not use rain snow elevation, so the input rain snow elevation time series (RSEL) is not needed, neither is the parameter “AREA_ELEV_CURVE(METR)” or “AREA_ELEV_CURVE(ENGL)”.
- iii) Does not use mods. However, SNOW17 techniques(PRINTSNW and SACSNEW) are still used.